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## CHAPTER 4

## SANITARY LANDFILL OPERATIONS

4-1. General. Proper site selection and design alone are insufficient to result in a landfill which provides for the protection of public health and the environment. To achieve such protection, operation of a landfill should be based upon these guidelines or other equivalent practices.

4-2. Criteria. A facility for the landfill disposal of solid waste should be operated in accordance with the following:

a. Acceptable wastes. In general, only wastes for which the facility has been specifically designed should be accepted for disposal; however, other wastes may be accepted if it has been demonstrated to the responsible agency that they can be satisfactorily disposed within the design capability or after appropriate facility modifications.

(1) Specific wastes, whose chemical, biological or physical characteristics are not compatible with disposal site design, location, or operation and which could pose an unacceptable environmental or health effect or pose a threat to the safety of personnel or users of the facility, should be prohibited from acceptance for disposal.

(2) PL 94-580 restricts the acceptance of any hazardous waste to landfills which were not specifically designed for that waste. Designer should note which of these wastes may be handled at each facility, and operating personnel should be made aware of any restrictions.

b. Cover material. Cover material should be applied, as necessary, to minimize fire hazards, odors, blowing litter, vector food and harborage; control gas venting and infiltration of precipitation; discourage scavenging; and provide an aesthetic appearance.

(1) A minimum of 6 inches of soil cover material should be applied daily.

(2) Cells which will not have additional wastes placed on them for 3 months or more should be covered with 12 inches of cover material.

(3) Most soil materials can satisfy the purpose of cover soil. However, if minimization of infiltration is necessary, relatively low permeability cover material should be utilized and placed at the steepest allowable grade in order to encourage runoff. Low permeability soils will remain effective only if the soil has a low

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shrink-swell potential or if the soil moisture can be maintained to prevent cracks from shrinkage and swelling.

(4) The completed landfill should be covered with 6 inches of clay or other suitable material with permeability equal to or less than  $1 \times 10^{-7}$  cm/second or equivalent, followed by a minimum cover of 18 inches of additional soil to complete the final cover and support vegetation. Deeply rooted vegetation may require an even greater depth of suitable soil.

c. Compaction. In order to conserve landfill disposal site capacity and preserve land resources, solid wastes should be incorporated into the landfill in the smallest practicable volume.

(1) For most solid waste materials, landfill compaction equipment is necessary for volume reduction.

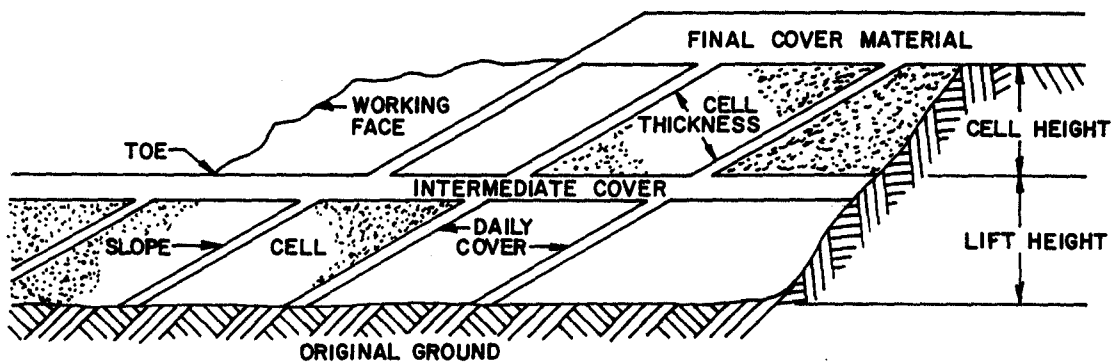
(2) Compaction or other volume reduction may take place at or before delivery to the landfill, by utilizing balers, shredders, or stationary compactors.

(3) Compaction of solid waste and cover soil reduces the attraction of rodents and vectors and the potential for fires.

(4) Open burning of solid waste for volume reduction should not be practiced at landfill disposal facilities.

4-3. Landfilling methods. The designer of a sanitary landfill should prescribe the method of construction and the procedures to be followed in the disposing of the solid waste, because there is no "best method" for all sites. The method selected depends on the physical conditions involved and the amount and types of solid waste to be handled. The two basic landfilling methods are trench and area; other approaches are only modifications. In general, the trench method is used when the ground water is low and the soil is more than 6 feet deep. It is best employed on flat or gently rolling land. The area method can be followed on most topographies and is often used if large quantities of solid waste must be disposed of. At many sites, a combination of the two methods is used.

a. Cell construction. The building block common to both methods is the cell. All the solid waste received is spread and compacted in layers within a confined area. At the end of each working day, or more frequently, it is covered completely with a thin, continuous layer of soil, which is then also compacted. The compacted waste and soil cover constitute a cell. A series of adjoining cells all of the same height makes up a lift (fig 4-1). The completed fill consists of one or more lifts.



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FIGURE 4-1. SANITARY LANDFILL CONSTRUCTION

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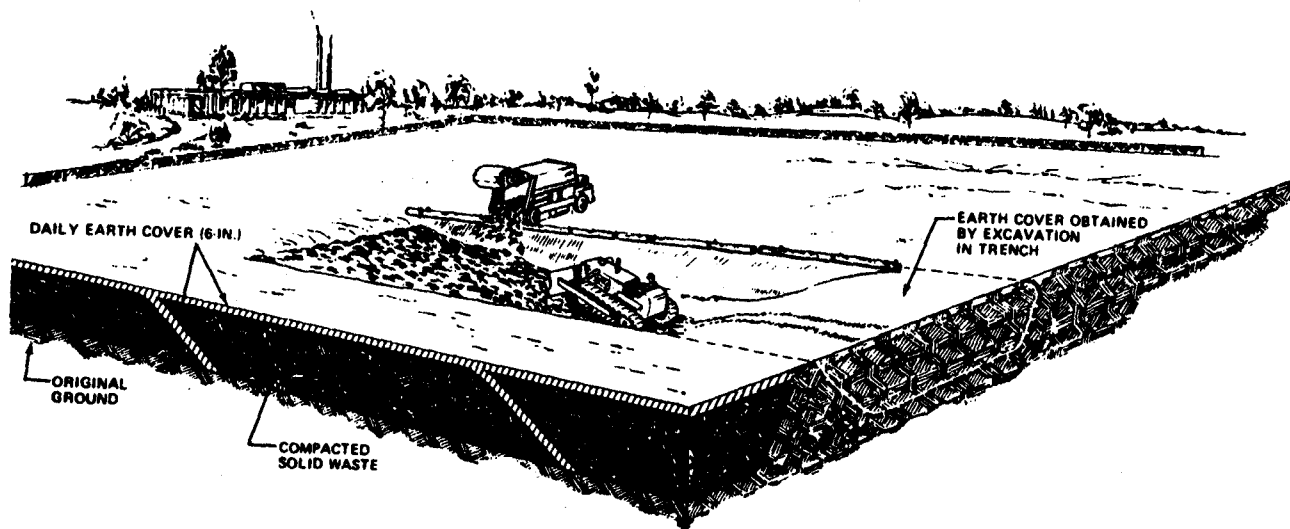
(1) The dimensions of the cell are determined by the volume of the compacted waste, and this, in turn, depends on the density of the in-place solid waste. The field density of most compacted solid waste within the cell for mobilization work should be at least 600 pounds per cubic yard. Higher figures may be difficult to achieve if trimmings from bushes and trees, plastic turnings, or synthetic fibers predominate. Because these materials normally tend to rebound when the compacting load is released, they should be spread in layers up to 2 feet thick, then covered with 6 inches of soil. Over this, mixed solid waste should be spread and compacted. The overlying weight keeps the fluffy or elastic materials reasonably compressed.

(2) An orderly operation should be achieved by maintaining a narrow working face (that portion of the uncompleted cell on which additional waste is spread and compacted). It should be wide enough to prevent a backlog of trucks waiting to dump, but not be so wide that it becomes impractical to manage properly--never over 150 feet.

(3) The height of a cell is not restricted. However, operations must be such that the required cover material is placed and compacted on a daily basis.

b. Cover material. Cover material volume requirements are dependent on the surface area of waste to be covered and the thickness of soil needed to perform particular functions. Cell configuration can greatly affect the volume of cover material needed. The surface area to be covered should therefore be kept minimal. In general, the cell should be about square, and its sides should be sloped as steeply as practical operation will permit. Side slopes of 20 to 30 degrees will not only keep the surface area, and hence the cover material volume, at a minimum but will also aid in shredding and obtaining good compaction of solid waste, particularly if it is spread in layers not greater than 2 feet thick and worked from the bottom of the slope to the top.

c. Trench method. Waste is spread and compacted in an excavated trench. Cover material, which is taken from the spoil of the excavation, is spread and compacted over the waste to form the basic cell structure (fig 4-2). In this method, cover material is readily available as a result of the excavation. Spoil material not needed for daily cover may be stockpiled and later used as a cover for an area fill operation designed for the top of the completed trench fill operation. Cohesive soils, such as glacial till or clayey silt, are desirable for use in a trench operation because the walls between the trenches can be thin and nearly vertical. The trenches can, therefore, be spaced very closely. Weather and the length of time the trench is to remain open also affect soil stability and must, therefore, be considered when the slope of the trench walls is being designed. If the trenches are aligned perpendicularly to the prevailing wind, this can greatly reduce the amount of blowing litter. The trench can be as deep as soil and ground water conditions safely allow, and it should be



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THE WASTE COLLECTION TRUCK DEPOSITS ITS LOAD INTO THE TRENCH WHERE THE BULLDOZER SPREADS AND COMPACTS IT. AT THE END OF THE DAY SOIL IS EXCAVATED FROM THE FUTURE TRENCH AND USED AS THE DAILY COVER MATERIAL.

FIGURE 4-2. TRENCH METHOD

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at least twice as wide as any compacting equipment that will work in it. The equipment at the site may excavate the trench continuously at a rate geared to landfilling requirements. At small sites, excavation may be done on a contract basis.

d. Area method. In this method, the waste is spread and compacted on the natural surface of the ground, and cover material is spread and compacted over it (fig 4-3). The area method is used on flat or gently sloping land and also in quarries, strip mines, ravines, valleys, or other land depressions.

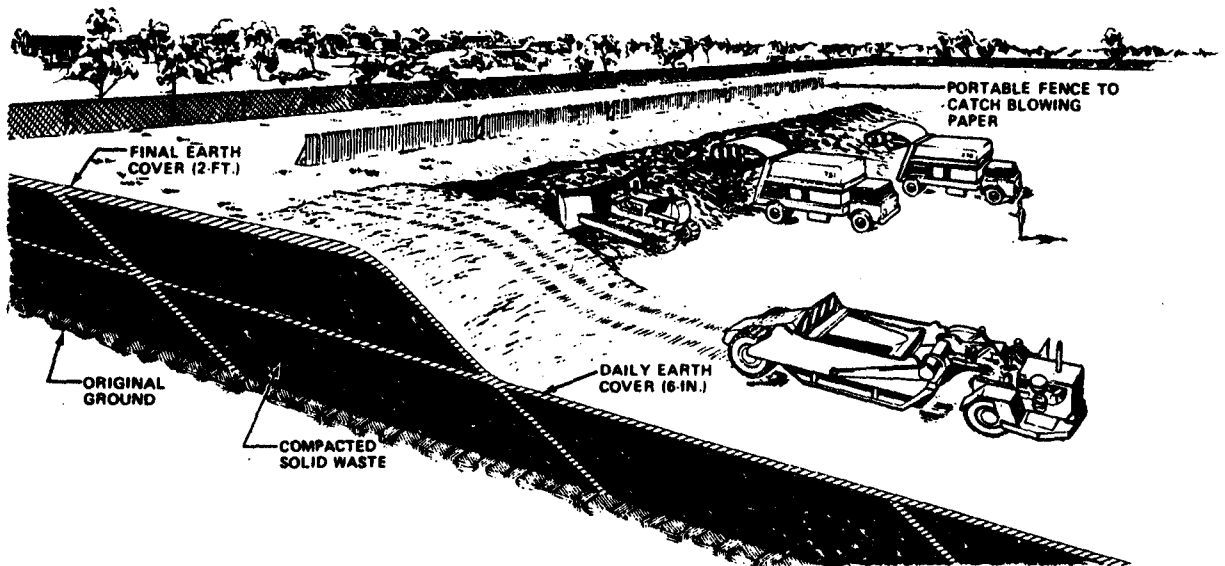
e. Combination methods. A sanitary landfill does not need to be operated by using only the area or trench method. Combinations of the two are possible, and flexibility is, therefore, one of sanitary landfilling's greatest assets. The methods used can be varied according to the constraints of a particular site.

(1) One common variation is the progressive slope or ramp method, in which the solid waste is spread and compacted on a slope. Cover material is obtained directly in front of the working face and compacted on the waste (fig 4-4). In this way, a small excavation is made for a portion of the next day's waste. This technique allows for more efficient use of the disposal site when a single lift is constructed than the area method does, because cover does not have to be imported, and a portion of the waste is deposited below the original surface.

(2) Both methods might have to be used at the same site if an extremely large amount of solid waste must be disposed of. For example, at a site with a thick soil zone over much of it but with only a shallow soil over the remainder, the designer would use the trench method in the thick soil zone and use the extra spoil material obtained to carry out the area method over the rest of the site. When a site has been developed by either method, additional lifts can be constructed using the area method by having cover material hauled in. The final surface of the completed landfill should be so designed that ponding of precipitation does not occur. Settlement must, therefore, be considered. Grading of the final surface should induce drainage but not be so extreme that the cover material is eroded. Side slopes of the completed surface should be 3 to 1 or flatter to minimize maintenance.

4-4. Equipment. The size, the type, and the amount of equipment required at a sanitary landfill depend on the size and method of operation and to some degree on the experience and preference of the designer and equipment operators.

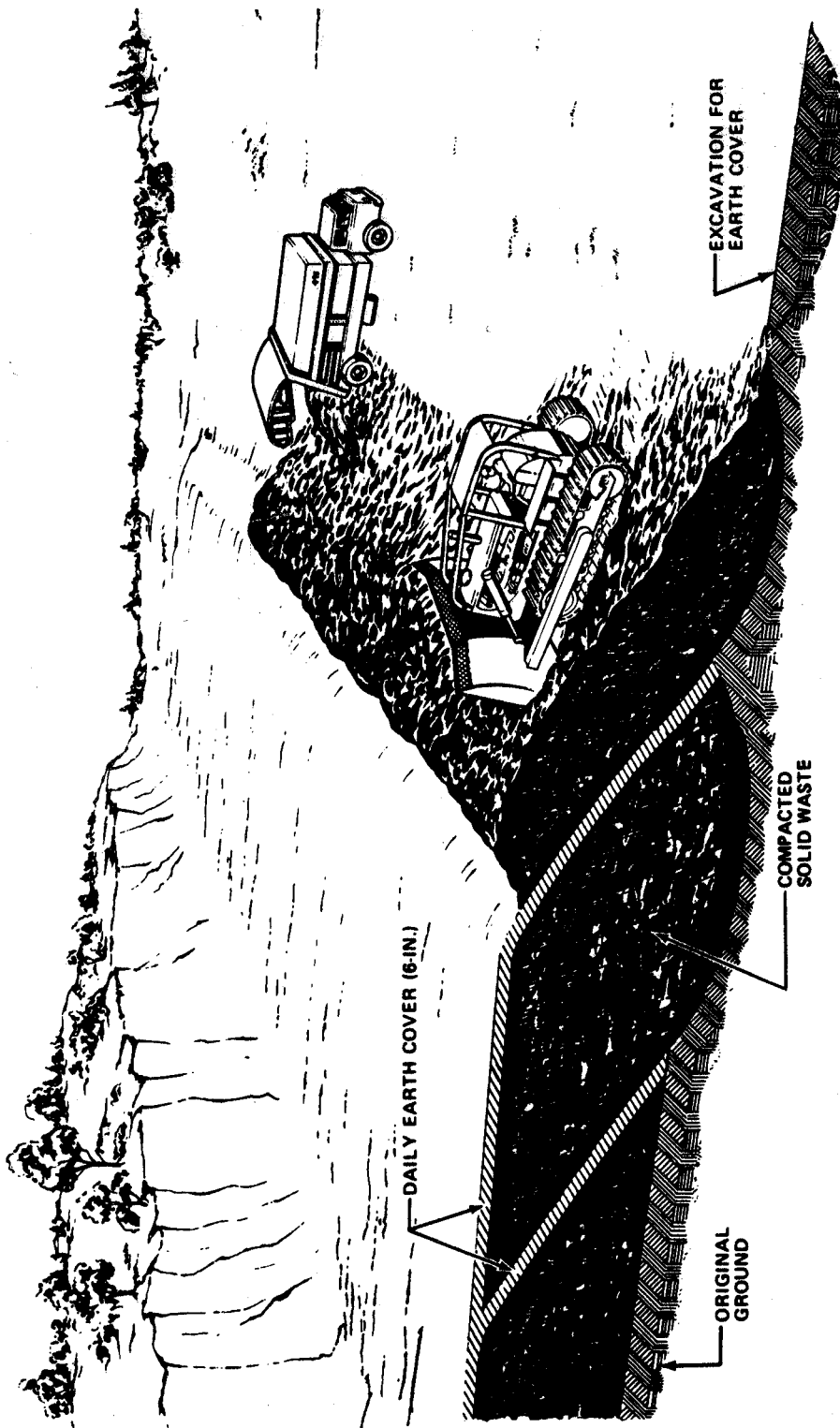
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THE BULLDOZER SPREADS AND COMPACTS SOLID WASTES. THE SCRAPER (FOREGROUND) IS USED TO HAUL THE COVER MATERIAL AT THE END OF THE DAY'S OPERATIONS. NOTE THE PORTABLE FENCE THAT CATCHES ANY BLOWING DEBRIS. THIS IS USED WITH ANY LANDFILL METHOD.

FIGURE 4-3. AREA METHOD



SOLID WASTES ARE SPREAD AND COMPACTED ON A SLOPE. THE DAILY CELL MAY BE COVERED WITH EARTH SCRAPED FROM THE BASE OF THE RAMP. THIS VARIATION IS USED WITH EITHER THE AREA OR TRENCH METHOD.

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FIGURE 4-4. PROGRESSIVE SLOPE METHOD

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a. Types. The most common equipment used on sanitary landfills is the crawler or rubber-tired tractor. The tractor can be used with a dozer blade, trash blade, or a front-end loader. A tractor is versatile and can normally perform all the operations: spreading, compacting, covering, trenching, and even hauling the cover material. The decision on whether to select a rubber-tired or a crawler-type tractor and a dozer blade, trash blade, or front-end loader must be based on the conditions at each individual site and the equipment's availability. Other equipment used at sanitary landfills are scrapers, compactors, draglines, and graders. This type of equipment is normally found only at large sanitary landfills where specialized equipment increases the overall efficiency.

b. Size. The size of the equipment is dependent primarily on the size of the operation. Small sanitary landfills for camps of 15,000 or fewer, or sanitary landfills handling 46 tons of solid wastes per day or less, can operate successfully with one tractor of the 5- to 15-ton range. Heavier equipment in the 15- to 30-ton range or larger can handle more waste and achieve better compaction. Heavy equipment is recommended for sanitary landfill sites serving more than 15,000 people or handling more than 46 tons per day.

c. Amount. Sanitary landfills servicing 50,000 people or fewer, or handling about 155 tons of solid wastes per day or less, normally can manage well with one piece of equipment, but provisions must be made for standby equipment. It is preferable that a second piece of equipment be used for replacement during breakdown and routine maintenance periods of the regular equipment. At large sanitary landfills serving more than 100,000 persons, or handling more than 310 tons of solid wastes per day, more than one piece of equipment will be required. At these sites, specialized equipment can be utilized to increase efficiency and minimize costs. In table 4-1, a general guide is given for the selection of the type, size, and amount of equipment for various sizes of sanitary landfills.

4-5. Effect of climate on sanitary landfill. Adverse climate can severely limit the capability of the sanitary landfill, but this can be partially overcome by preplanning and operational techniques.

a. Cold weather. Extremely cold weather can greatly reduce the biological activity in a sanitary landfill. In some regions where winter temperatures are less than minus 30 degrees F., only minimal waste stabilization occurs. A serious problem in cold regions is frozen soil. This can be overcome to some extent by excavating for the fill during the summer season and stockpiling cover material.

b. Wet weather. The major problem in wet weather is maintaining maneuverability of the refuse delivery vehicles and equipment. This can be provided in the design by selecting a site that is well drained

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Table 4-1. Average Equipment Requirements

Population	Daily tonnage	No.	Equipment		Accessory*
			Type	Size in lbs	
0 to 15,000	0 to 46	1	Tractor crawler or rubber-tired	10,000 to 30,000	Dozer blade Landfill blade Front-end loader (1- to 2-yd)
15,000 to 50,000	46 to 155	1	Tractor crawler or rubber-tired	30,000 to 60,000	Dozer blade Landfill blade Front-end loader (2- to 4-yd) Multipurpose bucket
		*	Scraper Dragline Water truck		
50,000 to 100,000	155 to 310	1 to 2	Tractor crawler or rubber-tired	30,000 or more	Dozer blade Landfill blade Front-end loader (2- to 5-yd) Multipurpose bucket
		*	Scraper Dragline Water truck		
100,000 or more	310 or more	2 or more	Tractor crawler or rubber-tired	45,000 or more	Dozer blade Landfill blade Front-end loader Multipurpose bucket
		*	Scraper Dragline Steel-wheel compactor Road grader Water truck		

\* Optional. Dependent on individual need.

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and with soil that has adequate trafficability when wet. Operational practices can also reduce the effect of this problem. Surface drainage can usually be diverted from open excavations by careful grading.

c.- Dry weather. Dry weather problems in a sanitary landfill are mainly operational such as blowing dust or paper. A certain amount of moisture is needed for the biological activity in the refuse; however, it is unusual to have to add water for this purpose. Control of blowing refuse can be accomplished by prompt covering and by the use of portable fences downwind of the open face of the fill.